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**I D Avramov, "IEEE International Frequency Control Symposium and PDA Exhibition Jointly with the 17th European Frequency and Time Forum", 2003, IEEE, pages 911-917**  
**Domínguez et al, "IEEE International Frequency Control Symposium", 1998, IEEE, pages 602-607**

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(54) **Abstract Title: Wireless SAW device excited by local oscillator which is powered by a remote power supply**

(57) A detector 1 (eg for measuring torque) comprises one or more SAW devices 2,3 each having connected to

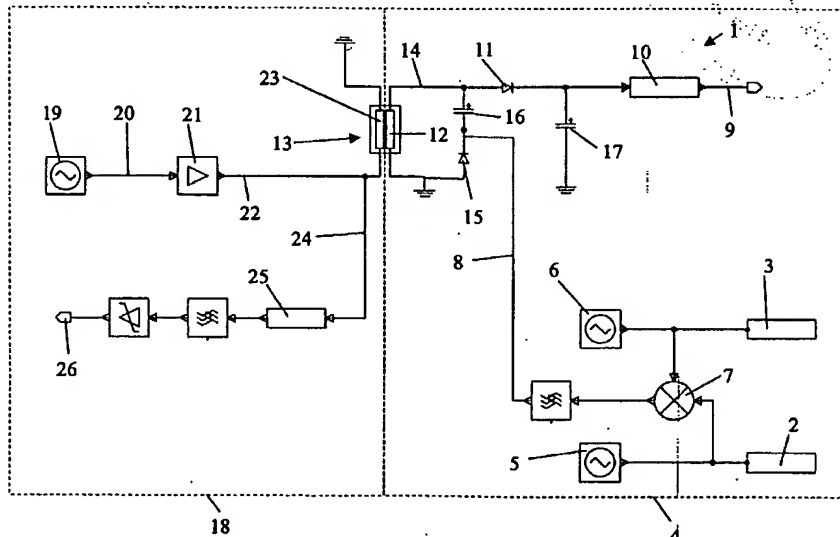


FIGURE 1

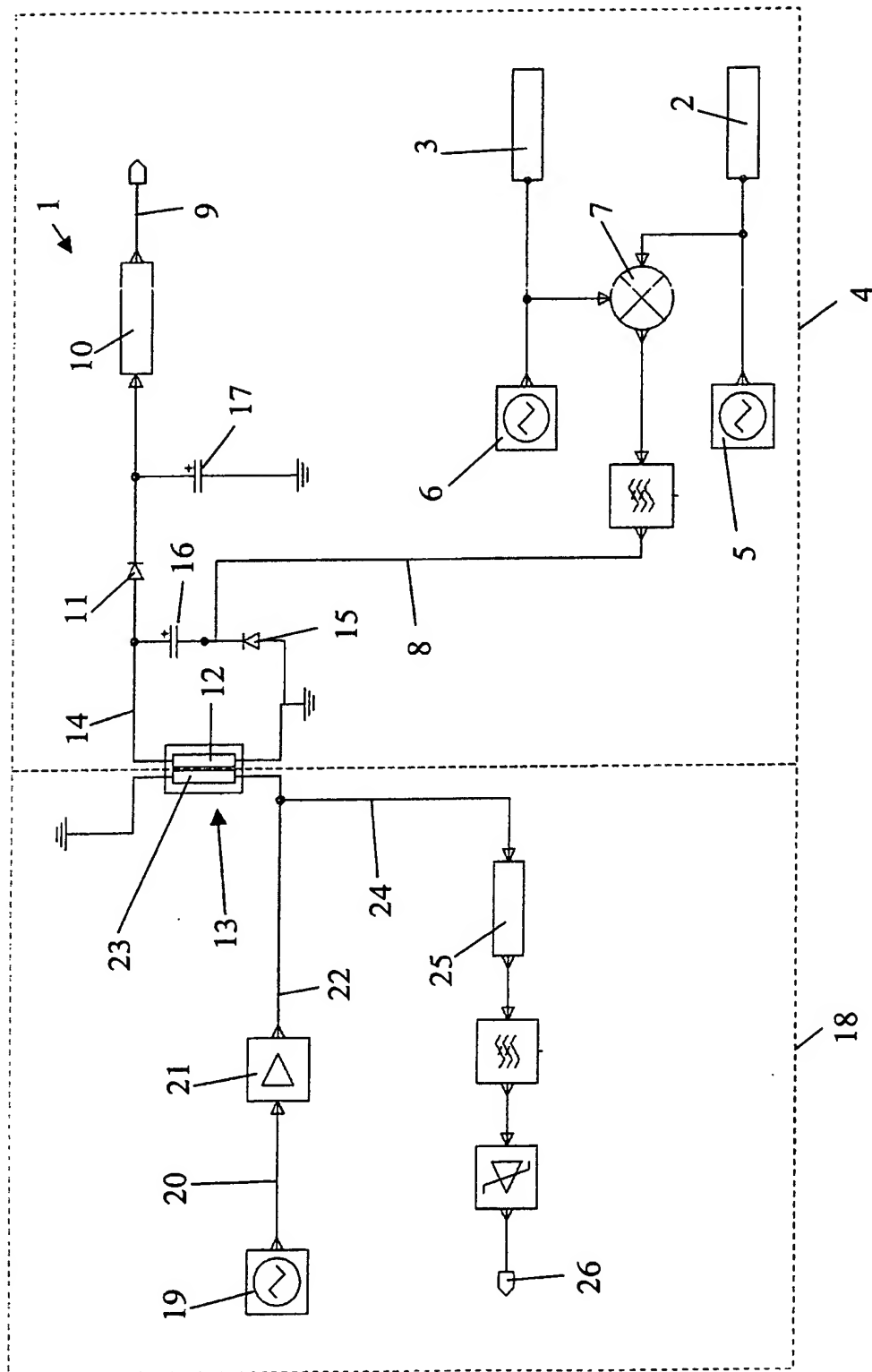


FIGURE 1

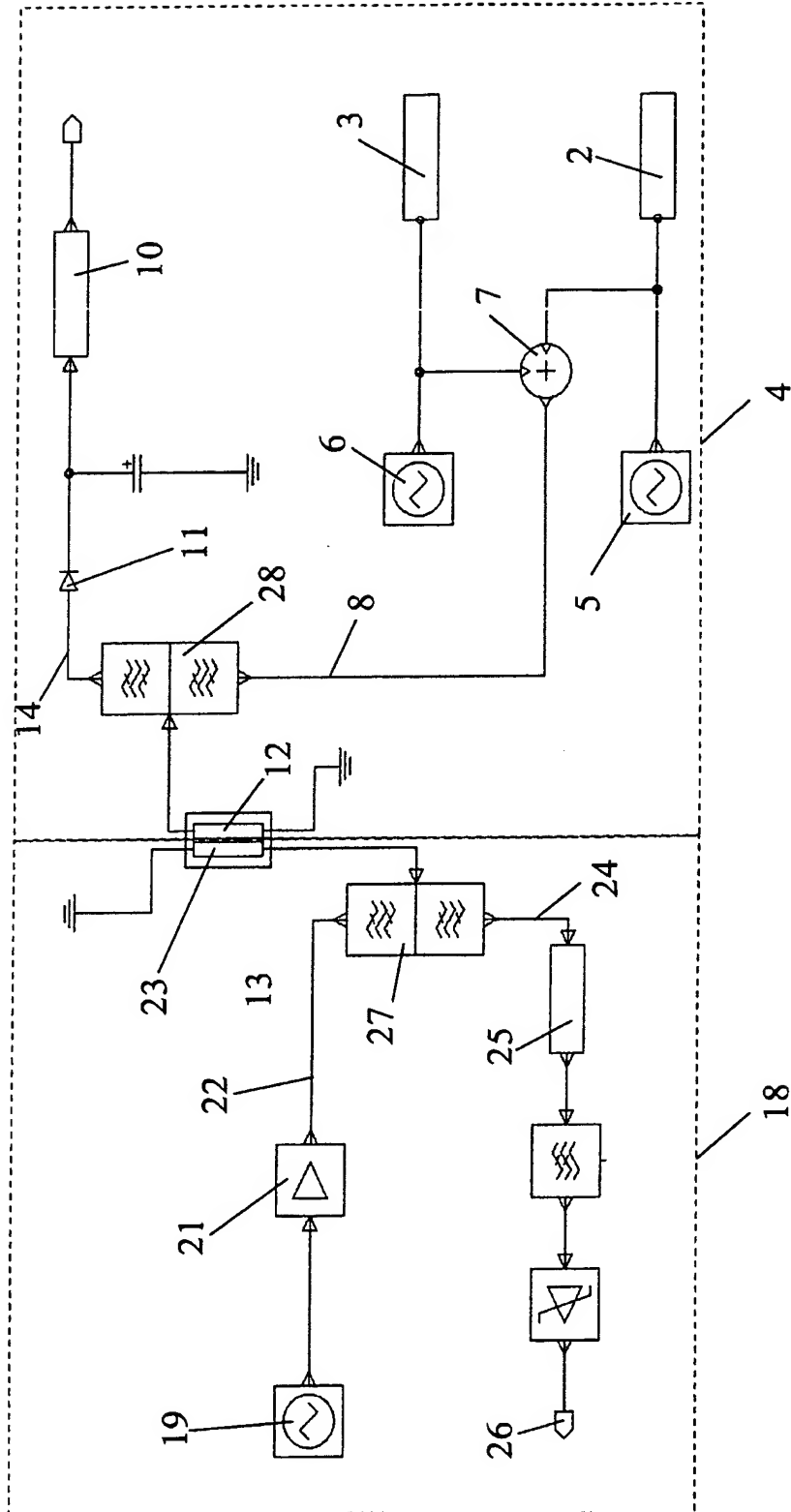


FIGURE 2

FIGURE 3

**IMPROVEMENTS IN AND RELATING TO DETECTORS  
UTILISING SAW DEVICES**

This invention relates to certain improvements in and relating to detectors utilizing Surface Acoustic Wave (SAW) devices.

It is known to use SAW devices as the change-sensitive element in detectors used for detecting the state or change of state of a system. The use of SAW devices in such systems is based upon the known characteristic of SAW devices that the characteristic frequency of a SAW device is dependent on the physical spacing of the electrodes laid down on the substrate of the device and the SAW velocity. If the electrode spacing and/or the SAW velocity changes as a result of, for example, a change of temperature of the substrate or mechanical stress applied to the substrate the characteristic frequency of the SAW device will change and this change can be utilized to detect and, with suitable calibration, measure, the change in the physical condition of an item. Typical uses of SAW devices are in torque measuring devices and pressure/temperature measuring devices.

A typical prior art SAW based torque measuring device is illustrated in GB-A-2328086. In this device the SAW device is secured to a shaft so that the substrate of the SAW device is deformed in a manner proportionate to the torque applied to the shaft. After suitable calibration, changes in the characteristic frequency or frequencies of the SAW device can be used to provide an indication of the torque transmitted by the shaft.

Heretofore, when SAW devices were utilized in applications where hard wiring to the SAW device is not possible (for example applications such as that shown in GB-A-2328086) the energizing signal which must be applied to the SAW device to produce a characteristic response has been generated remotely from the SAW device and has been transferred to the SAW device by means of a suitable coupling, for example a transmission line coupling as shown in GB-A-2328086 or an RF link as

shown in GB-A-2370640. The advantage of such an arrangement is that no power supply in the form of a primary or secondary electrical cell or battery is required in immediate juxtaposition to the SAW device. Accordingly, the SAW device may be located in positions where it would be difficult or impossible to change an electrical cell or battery and the size and weight of the components which must be located in an inaccessible or inconvenient position is kept to a minimum.

We have now devised an arrangement in which the oscillator necessary to excite the or each SAW device can be located in immediate juxtaposition to the respective SAW device and yet no local power supply need be located in immediate juxtaposition to the SAW device.

The term "local power supply" as used herein means a cell or battery which is located immediately adjacent a SAW device and which, by means of a chemical reaction, generates or stores electrical energy.

In accordance with the first embodiment of the invention a detector comprises a SAW device the characteristic frequency of which depends upon the value of a physical condition to be detected by the detector; an oscillator connected to the SAW device for exciting the SAW device; and a power supply for powering the oscillator, the power supply comprising means remote from the oscillator and the SAW device for generating a wave form, means local to the oscillator for receiving a wave form and extracting electrical power from the wave form to power the oscillator, and coupling means for coupling the means for generating the wave form to the means for receiving the wave form whereby energy may be transferred from the means for generating a wave form to the oscillator via the coupling and the means for receiving a wave form.

The coupling is preferably a non-contact coupling and may comprise an inductive, capacitive, a transmission line coupling, or wireless or an RF coupling by means of antennas. If the SAW device is mounted on a rotating shaft the coupling preferably comprises a rotary coupling.

In one embodiment of the invention, a single coupling is used both to transfer energy to the oscillator associated with the SAW device and to couple the output of the SAW device to suitable detection equipment for determining the characteristic frequency of the SAW device. Some processing of the SAW device signals may be carried out in the immediate vicinity of the SAW device, and the results of such processing may be transmitted to remote detecting or measuring equipment via the same coupling as that used to transmit power to the oscillator.

In an alternative arrangement separate couplings may be provided respectively for transmitting power to the oscillator and transmitting signals from the SAW devices to remote detection equipment.

The invention will be better understood from the following description of the preferred embodiments thereof, given by way of example only, reference being had to the accompanying drawings wherein:

Figure 1 illustrates a first embodiment of the invention;

Figure 2 illustrates a second embodiment of the invention; and

Figure 3 illustrates a third embodiment of the invention.

Referring firstly to Figure 1 the illustrated detector 1 comprises a first SAW device 2 and a second SAW device 3. The SAW devices are located within a region 4. The region 4 may, for example, be the surface of a rotating shaft. The SAW devices 2, 3 are excited by respective oscillators 5, 6 which are also located within the region 4. The outputs of the SAW devices 2, 3 are mixed in a mixer 7 to provide an output signal on line 8.

Power for the oscillators 5, 6 is supplied from the outlet 9 of a regulator 10. Power for the regulator 10 is derived from the output of a rectifier 11 the input of which is connected to the first part 12 of a coupler 13 by a line 14. The first part 12 of the coupler, together with the rectifier 11 and regulator 10, are all located within the first zone 4. The line 8 is also connected to the first part 12 of the coupler by a bridge comprising a varactor 15 and a capacitor 16. Some smoothing of the input to the

regulator 10 is provided by a capacitor 17.

A second zone 18 is located at a convenient position adjacent the first zone 4. The second zone 18 may, for example, be located on a fixed housing adjacent the rotating shaft upon which the zone 4 is located. The zone 18 houses an oscillator 19 which produces an oscillator output signal on line 20. The oscillator output signal is applied to a power amplifier 21 to produce a wave form on line 22. As illustrated, the oscillator 19 operates the frequency of 150MHz, although the exact frequency of operation of the oscillator is not critical. The line 22 is connected to the second part 23 of the coupling 13. The coupling 13 is effective to transfer energy from the wave form produced by the power amplifier to the line 14 for rectification by the rectifier 11 and regulation by the regulator 10 to produce power for the oscillators 5, 6.

The coupler 13 is also effective to transfer signal information from the line 8 to a line 24 which provides the input to a detector 25. The output of the detector 25 is suitably filtered to provide a signal on line 26 which is indicative of the frequency difference between the characteristic frequencies of the SAW devices 2, 3.

In the example illustrated, in an unstressed state of the characteristic frequencies of the oscillators 2, 3 are 200MHz and 201MHz respectively. Accordingly, when the SAW devices are in an unstressed state the output of the mixer 7 will be a 1MHz signal on line 8 which, after passage through the coupler 13 and appropriate detection and filtering will produce a 1MHz signal at the output 26. The SAW devices 2, 3 are arranged within the zone 4 so that they are affected differently by a change in condition to which they are sensitive. Thus, typically, if the detector is for measuring the torque in a shaft the outputs of the SAW devices 2, 3 will be arranged such that a change in applied torque will result in an increase in the characteristic frequency of one SAW device and a decrease in the characteristic frequency of another SAW device with the result that the difference signal will change to provide a measure of the change in applied torque.

It will be noted that the arrangement described above preserves all the inherent



advantages of known SAW device based detectors whilst, at the same time, enabling the oscillators needed to excite the SAW devices to be located in immediate juxtaposition to the SAW devices. Accordingly, the coupling 23 is not required to transfer the excitation frequency or frequencies necessary for excitation of the SAW devices. The coupling 13 may accordingly be optimized to transmit only the different signal provided on the line 8 and the power wave form provided on the line 22.

The coupling 13 may be of any convenient type and may, for example, be an RF transmission line coupling or an RF antenna coupling.

A second embodiment of the invention is illustrated in Figure 2. The arrangement of the components in Figure 2 is generally similar to that in the components in Figure 1 and like reference numerals have been used to identify like components. As with Figure 1, SAW devices 2, 3 and associated oscillators 5, 6 and mixer 7 are located within a zone 4 which may typically be on the surface of a rotating shaft. The oscillators 5, 6 are powered from the output of a regulator 10 which in turn receives an input from a rectifier 11. A power signal is provided on line 22 by an oscillator 19 and power amplifier 21 and a detector 25 and associated filters is used to provide an output signal 26.

The arrangement of Figure 2 differs, however, from the arrangement of Figure 1 in that the lines 22, 24 are connected to a duplexer 27 which is connected to the second part 23 of the coupling 13. The first part 12 of the coupling 13 is connected to a duplexer 28 to which the lines 8 and 14 are connected.

Referring now to Figure 3, many of the components are repeated from the previous embodiments. Such components are referenced with like reference numerals and description of the embodiments set out above provides details of the nature and operation of these components. In the embodiment of Figure 3, however, the single coupler 13 of the embodiments of Figures 1 and 2 has been replaced by two couplers 13A and 13B respectively. The coupler 13A includes a first part 12A which is connected to the line 14 and a second part 23A which is connected to the line 22.

Coupler 13B includes a first part 12B which is connected to the line 8 and a second part 23B which is coupled to the line 24. With such an arrangement the respective couplers 13A, 13B are each required only to handle one signal and may be optimized for the signal in question.

Although the invention has been described with reference to particular embodiments it should be appreciated that the invention may be applied to any detector using a SAW device and is especially advantageous in circumstances where it would be difficult or impossible to provide hard wiring from a power source to the or each oscillator functioning to excite a SAW device. Further, although the invention has been described with reference to particular types of coupling it should be appreciated that any coupling capable of providing the requisite signal transfer may be utilized in embodiments of the invention.

Claims

1. A detector comprising a SAW device having a characteristic frequency which is dependent upon the value of a physical condition to be detected by the detector, an oscillator located locally to and connected to the SAW device for exciting the SAW device, and a power supply for powering the oscillator, the power supply comprising means remote from the oscillator and the SAW device for generating a wave form, means local to the oscillator for receiving a wave form and extracting electrical power therefrom to power the oscillator, and coupling means for coupling the means for generating the wave form to the means for receiving the wave form, whereby energy may be transferred from the means for generating a wave form to the oscillator via the coupling means and the means for receiving a wave form.
2. A detector according to claim 1, wherein said coupling means is a non-contact coupling means.
3. A detector according to claim 2, wherein said non-contact coupling means comprises a an inductive, capacitive, transmission line coupling or an RF wireless coupling.
4. A detector according to any of the preceding claims, wherein said coupling means is a rotary coupling.
5. A detector according to any of the preceding claims, further including a second SAW device having a second characteristic frequency and a second oscillator located locally to said second SAW device, said power supply powering both said first and second oscillators through said coupling means.

6. A detector according to any of the preceding claims, further including processing means local to the at least one SAW device for processing the output signal of the or each SAW device.
7. A detector according to any of the preceding claims, wherein said coupling means is a bi-directional coupler which both transfers energy to the oscillator associated with the or each SAW device and transfers the output of the or each SAW device to detection means remote from the or each SAW device.
8. A detector according to any of claims 1 to 6, comprising second coupling means which transfers the output of the or each SAW device to detection means remote from the or each SAW device.
9. Any of the detectors substantially as herein described with reference to the accompanying drawings.



Application No: GB0400168.1

Claims searched: 1-9

9

Examiner: Stephen Jennings

Date of search: 5 May 2004

## Patents Act 1977: Search Report under Section 17

### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular reference
X	1-4,6-7	DE10018621 A1 [Siemens], see figures 1 and 2
X,P	1-3,6-7	I D Avramov, "IEEE International Frequency Control Symposium and PDA Exhibition Jointly with the 17th European Frequency and Time Forum", 2003, IEEE, pages 911-917 "The RF Powered Surface Wave Sensor Oscillator - A Successful Alternative to Passive Wireless Sensing", whole document relevant
X	1-3,6-7	Dominguez et al, "IEEE International Frequency Control Symposium", 1998, IEEE, pages 602-607 "Performance of an Embedded SAW Sensor for Fliter Bed Monitor and the Development of a Wireless Monitoring Prototype System", see especially right hand column on page 604 and figure 3

### Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

### Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>W</sup> :

G1G; G1N

Worldwide search of patent documents classified in the following areas of the IPC<sup>07</sup>

G01D; G01L

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, JAPIO, Internet